		USQ #N/A
SPREADSHEET DEVELOPMENT	Manual	**Engineering**
AND VERIFICATION	Document	**TFC-ENG-DESIGN-C-32, REV B-11**
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	Issue Date	**June 2, 2009**
	Effective Date	**June 2, 2009**

Ownership matrix

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1.0   PURPOSE AND SCOPE
(7.1.1)

This procedure provides requirements for the development, documentation, and verification of spreadsheets. This procedure applies to all Washington River Protection Solutions, LLC (WRPS) personnel (and staff augmentation) using spreadsheets for performing calculations or data manipulation in technical documents or in support of other technical activities. The procedure also provides requirements for task-based subcontractors on the use of this procedure when it is specified in a contract or statement of work.

Spreadsheets generated by the 222-S Analytical Laboratory are subject to the requirements of this procedure plus additional Laboratory-specific requirements described in ATS-310, Section 8.14, "Computer Software Management."

Spreadsheets that are exempted from the requirements of this procedure include:

- Business or financial spreadsheets

- Spreadsheets that do not perform calculations or do not perform technical data manipulation

- Spreadsheets that are used for administrative type activities (such as table generation)

- Computation type spreadsheets as defined in Section 5.0

- Spreadsheets that are generated as a result of a query or download from TWINS, or other system registered on the Hanford Information Systems Inventory (HISI), provided that nothing is done to modify the data

- Spreadsheets that are generated as output from software that has been previously developed and verified in accordance with TFC-BSM-IRM_HS-C-01

- Spreadsheets that are used to check or to verify the results of another spreadsheet, software, or other calculation.

  NOTE: Although exempted from the requirements of this procedure, the spreadsheets listed above may be documented and released for tracking purposes on the Spreadsheet Verification Form at the discretion of the manager responsible for the spreadsheet.

2.0   IMPLEMENTATION

This procedure is effective on the date shown in the header. All spreadsheets developed or released in documents after the effective date shall meet the requirements of this procedure. Spreadsheets that have been verified under previous revisions of this procedure (or its predecessor TFC-ENG-CHEM-D-33) do not require re-verification solely to meet the requirements of this procedure, unless revised. Single-use spreadsheets that were originally issued or released prior to 6/08/07 will not be required to meet the documentation and verification requirements of this procedure, unless revised after 6/08/07. . Multiple-use spreadsheets which are to remain in use shall be brought into compliance with the documentation and verification requirements of this procedure at the time of their next update or revision. HISI

Version Description Documentation for critical spreadsheets issued or revised before the effective date of this procedure and after 6/08/07 shall be completed by 09/30/09.

3.0 RESPONSIBILITIES

1. The developer/owner of a spreadsheet shall be a technically competent individual with the appropriate education, experience, and expertise to perform the calculations and develop the spreadsheet contemplated.

2. The verifier of a spreadsheet shall be a technically competent individual with the appropriate education, experience, and expertise to perform the calculations and develop the spreadsheet contemplated and shall be someone other than the spreadsheet developer/owner. If the spreadsheet contains macros, the verifier shall be sufficiently familiar with macro development to be able to adequately verify the included macros. The verifier can be from the same organization as the developer/owner but shall not have been directly involved in development of the specific spreadsheet revision being verified.

Other responsibilities are contained within Section 4.0.

4.0 PROCEDURE

A flowchart of the spreadsheet development and verification process is provided in Figure 1.

This procedure should generally be followed in the order written. However, steps may be performed in parallel or out of sequence as required. Section 4.2 provides guidance information on software selection. The steps in this section are not mandatory. Section 4.4, steps 2 and 3, and the attachments to this procedure also provide guidance and, while recommended, are not mandatory.

4.1 Background

The availability and relative ease of use of spreadsheets makes them a common and popular tool for performing numerical calculations. The use of macros, "add-ins," and the ability to link multiple worksheets and/or workbooks allows users to build powerful but very complicated spreadsheets. However, some features of spreadsheets make it difficult for users to find and correct mistakes, warranting extra attention when spreadsheets are used to perform engineering and technical calculations. Two examples of the spreadsheet characteristics that make it difficult to find and eliminate errors are: 1) the inherent structure of a spreadsheet tends to hide formulas in favor of displaying the results of the calculation, and 2) the use of cell references as opposed to standard engineering symbols makes spreadsheet formulas more difficult to read and understand, particularly when formulas reference across multiple worksheets.

The acknowledgement of the inherent risk and error associated with spreadsheets has increased the focus on spreadsheets and made them a routine subject of external audit. These risks prompted the development of this procedure and its predecessors and warrant additional considerations for the verification of spreadsheets relative to other calculation tools.

This procedure uses a graded approach to documentation and verification, depending on the complexity and end use of the spreadsheet.

4.2 **Software Selection**
(7.1.1)

Understanding the problem to be solved, determining whether a spreadsheet is the most appropriate tool to use to solve the problem, and appreciating the potential scale and complexity of a spreadsheet will ensure that the appropriate tool is selected for the problem.

Responsible Manager

1. Define the problem to be solved and assign a qualified engineer/analyst to be the spreadsheet developer and owner.

   NOTE: Qualification requirements are defined in Section 3.0.

Spreadsheet Developer/Owner

2. Review the problem to be solved and ensure that the objectives are clearly understood and defined.

3. Determine the anticipated level of complexity of the spreadsheet, considering:

   - The quantity of data to be handled and from where it will be obtained

   - The calculation methods and formulas that will form the basis for the spreadsheet

   - Whether the calculations require iteration

   - What results are required and how will they be used

   - If the spreadsheet will be used once or multiple times

   - If the spreadsheet contains multiple worksheets and/or links to external spreadsheets

   - If the spreadsheet requires the use of macros

   - If the spreadsheet requires the use of "add-in" software to perform the calculations

   - How the spreadsheet will be checked for accuracy.

4. Based on the anticipated complexity of the spreadsheet, determine whether a spreadsheet is the most appropriate tool for performing the calculations, considering the following:

   a. If the spreadsheet would be performing a single-use engineering calculation, utilizing standard engineering formulas, with limited repetition of calculations and limited input data sets, MathCAD[1] or other Commercial-off-the-Shelf (COTS) engineering software may be a more suitable tool and

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[1] MathCAD is a product of Mathsoft Engineering and Education Inc., Cambridge, Massachusetts.

provide clearer presentation of the calculation methodology. If using such software, exit this procedure and follow TFC-ENG-DESIGN-C-10.

b. If the spreadsheet would be multiple-use, contain repetitive complex blocks of calculations, require additional non-standard calculation methods such as provided by Microsoft® Excel[2] "add-ins," and contain iterative calculations, a custom software application may be a better tool, provide greater confidence in configuration control, and provide easier understanding and testing of the complex calculations. If using such software, exit this procedure and follow TFC-BSM-IRM_HS-C-01.

c. If the spreadsheet would be multiple-use and make extensive use of tank characterization data available on the Tank Waste Information Network System (TWINS), a custom software application on TWINS may provide greater confidence in configuration control and provide the ability for direct data loading from the TWINS database. If using such software, exit this procedure.

Otherwise, proceed to step 5.

5. If a spreadsheet is considered the most appropriate tool for performing the desired calculations or data manipulation, or other considerations preclude the use of alternate software, proceed to Section 4.3.

4.3   Determination of Spreadsheet Category

The approach to spreadsheet development, documentation, and verification in this procedure uses a graded approach based on the complexity and use of the spreadsheet. Spreadsheets used once for a non-critical application require less development time, documentation, and effort in verification than do spreadsheets used multiple-times, by multiple users to verify compliance with technical safety requirement (TSR) limits.

Spreadsheet Owner's Manager

1. Review and agree with the spreadsheet developer's/owner's determination from Section 4.2 that a spreadsheet is an appropriate tool for the problem.

2. In conjunction with the spreadsheet developer/owner, determine and agree on the category of spreadsheet using the definitions provided in Section 5.0.

3. Determine whether a published report will be required to document the spreadsheet and its results.

NOTE: Formal documents are required for critical spreadsheets. Considerations for whether a formal report is required for a non-critical

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[2] Microsoft® Excel is a product of Microsoft Corporation, Redmond, Washington.

spreadsheet may include: the spreadsheet results represent a design baseline calculation; the results require presentation to external regulators or to the Office of River Protection, etc.

4. Provide initial agreement on the degree of data entry validation that will be performed for non-critical spreadsheets; e.g., spot-checked or 100% checked. Final agreement will be reached following spreadsheet development.

Spreadsheet Developer/Owner

5. Ensure that spreadsheets are developed with the site-standard version of Microsoft Excel available from HLAN.

6. For non-critical and critical spreadsheets, proceed to Section 4.4 and subsequent sections of this procedure and follow the steps applicable to the selected spreadsheet category.

4.4   Spreadsheet Development

Time spent prior to spreadsheet construction in understanding how the spreadsheet will work, the data required, the formulas and logic to be used, and in following good design principles in constructing the spreadsheet, will ensure that the final spreadsheet is easier to use, is focused on the important issues, is easier to understand and hence test, and is more efficient and reliable. The degree of application of these principles will depend on the category of spreadsheet with critical or multiple-use spreadsheets warranting more development time than non-critical spreadsheets.

Spreadsheet Developer/Owner

1. Ensure that the problem to be solved and the end use of the spreadsheet are clearly understood.

2. Design and construct the spreadsheet, paying particular attention to the good spreadsheet design practices provided in Attachment A.

3. Consider the spreadsheet hints and tips provided in Attachment B during construction of the spreadsheet.

4. Enter a file name for the spreadsheet that ties the spreadsheet to the purpose for its creation. The primary associated document number and revision number, or SVF number and revision number can be used in the file name to accomplish this. Provide a sequential version number for the spreadsheet (not necessarily the same as the SVF revision number) that allows revisions to the spreadsheet to be identified.

    NOTE: If more than one spreadsheet is associated with the same document, additional information shall be included in the file name to distinguish between spreadsheets.

5. Once the initial spreadsheet development has been completed, conduct a self check of the spreadsheet by completing steps 6 through 9.

6. Use the built-in features of Excel to detect any obvious errors in spreadsheet formulas. These features include:

    - Tools>Error Checking
    - Tools>Formula Auditing>Trace Error.

7. Resolve the error values resulting from step 6.

8. Perform a self-check of the spreadsheet to verify that all unique formulas contained in the spreadsheet correctly implement the intended functions and/or calculations prior to submitting the spreadsheet for checking. Pay particular attention to the commonly found errors indicated in Attachment C.

9. As applicable, perform a self-check of the input data entered into the spreadsheet using the techniques indicated in Section 4.6.2.

    NOTE: "Master" multiple-use spreadsheets will not normally have input data that requires verification. However, there may be cases in which a "master" spreadsheet contains standard data that are used in the spreadsheet in addition to case specific data. This "standard" data shall be checked and verified as discussed in Section 4.6.2.

10. Document the spreadsheet as indicated in Section 4.5.

    NOTE: If any errors are detected during the self-check that would impact previously published spreadsheet results, document and resolve the issue using the PER process (TFC-ESHQ-Q_C-C-01).

4.5   Spreadsheet Documentation
(7.1.1)

The level of documentation required for a spreadsheet will depend on its complexity, use, and risk. Non-critical spreadsheets require minimal formal documentation, whereas critical spreadsheets performing checks of TSR compliance require more formal documentation.

4.5.1   Non-Critical Spreadsheets

Spreadsheet Developer/Owner

1. Include a "documentation" worksheet as a worksheet in the spreadsheet. Include the following basic information on the documentation worksheet that will assist a verifier or future user of the spreadsheet in understanding the working of the spreadsheet:

    - Spreadsheet owner/developer

    - Simple description of the objective/purpose of the spreadsheet

- Basic overview of the spreadsheet structure and method (this need not be an extensive description; a few sentences or paragraphs are adequate)

- Description of any macros or add-in software

- Description of any key assumptions used in the spreadsheet

- Brief discussion of the input data used in the spreadsheet and reference to its source (reference to the source of the data may be accomplished on the worksheets containing the data. If the spreadsheet is a multiple-use spreadsheet, a discussion of the typical source of the input data on the master spreadsheet is included).

- Reference to the current Spreadsheet Verification and Release Form number from Section 4.6.

- If produced, reference to the Spreadsheet Description Document discussed in step 2.

NOTE: If a Spreadsheet Description Document is produced, the information included on the documentation worksheet should be a brief summary of that provided in the document, but should still cover the required elements above.

2. If Section 4.3, step 3, determined that a formally released technical document was required, document the spreadsheet in a Spreadsheet Description Document that is released in accordance with TFC-ENG-DESIGN-C-25.

   NOTE 1: A template for a Spreadsheet Description Document is available either from Site Forms (A-6004-005) or from Word under New> WRPS. Use of the template is optional.

   NOTE 2: If a spreadsheet is documented in a formally released calculation document prepared in accordance with the requirements of TFC-ENG-DESIGN-C-10, a separate Spreadsheet Description Document would not be required, provided that the description in the calculation document includes the items in the template for a Spreadsheet Description Document.

3. If a formal document is not required, proceed to step 4.

   NOTE: The spreadsheet itself will be the end product, together with the Spreadsheet Verification and Release Form discussed in Section 4.6.

4. If the spreadsheet is a multiple-use spreadsheet, complete the additional steps indicated in Section 4.5.3, then return to step 5.

5. Complete verification in accordance with Section 4.6 prior to relying on the spreadsheet results.

4.5.2   Critical Spreadsheets

Spreadsheet Developer/Owner

1. Include a "documentation" worksheet as a dedicated worksheet in the spreadsheet. Include the following information on the documentation worksheet that will assist a verifier or future user of the spreadsheet in understanding the working of the spreadsheet:

   - Spreadsheet owner/developer

   - Simple description of the objective/purpose of the spreadsheet

   - Basic overview of the spreadsheet structure and method (the extent of discussion should be commensurate with the importance of the spreadsheet)

   - Description of any macros or add-in software used

   - Description of any key assumptions used in the spreadsheet

   - Brief discussion of the input data used in the spreadsheet and reference to its source (reference to the source of the data may be accomplished on the worksheets containing the data. If the spreadsheet is a multiple-use spreadsheet, a discussion of the typical source of the input data on the master spreadsheet is included).

   - Reference to the current Spreadsheet Verification and Release Form number from Section 4.6.

   - Reference to the Spreadsheet Description Document required by step 2.

   NOTE: The information included on the documentation worksheet should be a brief summary of that included in the Spreadsheet Description Document required by step 2, but should still cover the required elements above.

2. For all critical spreadsheets, document the spreadsheet in a formally released Spreadsheet Description Document that is released in accordance with TFC-ENG-DESIGN-C-25 (see section 4.7).

   NOTE 1: A template for a Spreadsheet Description Document is available either from Site Forms (A-6004-005) or from Word under New> WRPS. Use of the template is optional.

   NOTE 2: If a spreadsheet is documented in a formally released calculation document prepared in accordance with the requirements of TFC-ENG-DESIGN-C-10, a separate Spreadsheet Description

Document would not be required, provided that the description in the calculation document includes the items in the Spreadsheet Description Document template.

3. Register the spreadsheet in HISI. The following fields are required at a minimum for registration:

- Registration Form (Core Information)

- Business Category

- Hanford Contacts, including at a minimum, the Owner Manager, Owner Project Lead, Project Lead, and Technical Support Manager

- Software Quality and Safety Checklist (SQSC).

NOTE: See HISI User Guide for definitions, contact info and guidance on completing HISI fields required above. Anyone with an HID number should be able to create an initial registration in HISI. After the initial registration is created, in order to update or edit information about an application in HISI, you must first be designated as a Hanford contact for that application within HISI. If you are a contact for an application but you are not yet listed as such in HISI, then you will need to notify either the Technical Support manager or the project lead listed for the application and request that he/she add your name as a contact point.

4. Submit the SQSC in HISI for approval.

HISI Approvers

5. Review and approve the SQSC in HISI. Resolve any comments with the spreadsheet developer/owner.

NOTE: The HISI approvers are identified in the HISI User Guide.

Spreadsheet Developer/Owner

6. If the spreadsheet is a multiple-use spreadsheet, complete the additional steps indicated in Section 4.5.3, then return to step 7.

7. Complete verification in accordance with Section 4.6 prior to release of any Spreadsheet Description Document and/or technical document that relies on the spreadsheet results.

4.5.3   Multiple-Use Spreadsheets

Spreadsheet Developer/Owner

1. For multiple-use spreadsheets, include a "change log" on a separate worksheet that for each version of the spreadsheet provides the following information:

- Version number

- A description of the change

- The name of the person making the change

- The date of the change

- The name of the person verifying the change

- The date of verification

- Reference to the corresponding Spreadsheet Verification and Release Form number from Section 4.6.

2. For multiple-use spreadsheets that will be used by multiple users, include a separate worksheet containing "user instructions" that guide a user on how to use the spreadsheet.

   NOTE 1: If the means of access to the spreadsheet is via a form or other similar means, the instructions may additionally be provided on the form.

   NOTE 2: Depending on the number and type of users for a spreadsheet, the documentation, change log, and/or user instructions worksheets may be hidden prior to making the spreadsheet available to the users, if it is considered that these additional worksheets may complicate understanding by the user. The user instructions worksheet may only be hidden if user instructions are provided via a form or other similar means as discussed above. All worksheets must remain unhidden during verification and in the copy of the spreadsheet submitted to the Document Release Station.

3. If a formal Spreadsheet Description Document has been determined to be required by either Section 4.5.1 or 4.5.2, the complete spreadsheet description is only required to be written once for the initial version of the "master" multiple-use spreadsheet (and updated for subsequent versions). Documents or calculations that describe the results of specific cases that are evaluated using the multiple-use spreadsheet do not require this complete description of the spreadsheet and can simply reference the document number of the Spreadsheet Description Document for the general information. Case-specific information, such as input data, should be included in the case-specific documents.

   NOTE: As discussed previously, formal documents are optional for non-critical spreadsheets as determined in Section 4.3, step 3.

4. Complete remaining documentation steps from Section 4.5.1 or 4.5.2, as applicable, depending on the category of spreadsheet.

4.6   Spreadsheet Verification
(7.1.1)

Verification of all single-use and multiple-use spreadsheets is required prior to their use or reliance on their results, unless those spreadsheets are exempted from the requirements of this procedure as discussed in Section 1.0. Verification consists of three stages: (1) reviewing and verifying the assumptions/limitations of the spreadsheet are reasonable and adequate; (2) verifying that the cell formulas included in the spreadsheet accurately reflect and perform the intended functions, equations, and calculations; and (3) verifying that input data used in the calculations were correctly entered into the spreadsheet.

4.6.1   Spreadsheet Formula Verification

Spreadsheet Owner's Manager

1.   Assign a qualified engineer/analyst to be the verifier of the spreadsheet.

NOTE: Qualification requirements are defined in Section 3.0.

Spreadsheet Developer/Owner

2.   Complete a self-check of the spreadsheet as required by Section 4.4, and document the spreadsheet and its results as required by Section 4.5.

3.   Obtain a Spreadsheet Verification and Release Form (SVF) from Site Forms (A-6003-781) or from Microsoft Word >New> WRPS. Instructions are included with the SVF form and must be followed when completing the form for all spreadsheets.

4.   Obtain a SVF number from the Hanford Document Numbering System (HDNS) and enter in block 1 of the SVF.

NOTE: The format of the number is SVF-XXXX Rev. N, where: SVF = Spreadsheet Verification and Release Form, XXXX is a sequential four digit number, and N is a sequential numeric revision number starting at 0 for the initial release.

5.   Complete blocks 1 through 6a of the SVF using the instructions included with the form.

6.   Meet with the assigned verifier, as necessary, to provide an overview explanation of the spreadsheet purpose and method so that the verifier can review the spreadsheet in context and advise verifier of any special checking requirements established by Section 4.3.

7.   Provide the SVF, spreadsheet documentation (as required), associated documents (as appropriate), and electronic copy of spreadsheet to the assigned verifier for checking.

8.   In conjunction with the verifier and spreadsheet owner's manager, agree on the scope of the verification, and complete blocks 7 and 8 of the SVF in accordance with the form instructions.

NOTE: The extent of verification should be commensurate with the category and use and risk of the spreadsheet. This should be described in blocks 7 and 8 of the SVF. For new single-use spreadsheets, the

scope will typically include all formulas and any macros or add-in software, plus the input data used in the spreadsheet. For multiple-use spreadsheets, the initial verification will typically include only the formulas, macros, add-in software, and any "standard" data used in the spreadsheet. Following initial verification, subsequent uses of a multiple-use spreadsheet will normally only require verification of the input data. For revisions to previously verified spreadsheets, only the spreadsheet changes normally require verification, unless the change is a major change.

Verifier   9.   Using a hard copy printout and/or an electronic copy of the spreadsheet, check the spreadsheet and associated worksheets to verify that the spreadsheet formulas are correct and the spreadsheet returns the correct results, using one or more of the accepted methods indicated below.

a.   For each unique cell formula, review the cell formula to determine that it performs the intended algebraic equation or logical expression and for non-unique formulae (i.e., the same formula applied to a series of data values), review the overall series for consistency to ensure the formulae have not been corrupted or incorrectly copied.

b.   Perform an alternate calculation by hand, alternate spreadsheet, Mathcad, or other means, and compare the results of the alternate calculation to the spreadsheet results to verify that the spreadsheet performs the intended functions and returns the correct results.

c.   If previously published and verified data is available, use this data as test data for the spreadsheet by entering the published input data into the spreadsheet and confirming that the spreadsheet returns the same result as published.

d.   Compare spreadsheet results with field measurements or analytical data, when appropriate, to confirm that the spreadsheet results are in reasonable agreement with the measured values.

NOTE 1: Checking must always be performed on a copy of the spreadsheet and not on the original spreadsheet in order to ensure independence of the spreadsheet developer/owner and the verifier. The spreadsheet developer/owner is responsible for maintaining the original spreadsheet and for modifying it as necessary to address comments provided by the verifier.

NOTE 2: Alternate calculations (b) and testing (c) are the preferred methods to perform this step. When performing hand calculations or other alternate calculations to verify a spreadsheet, the results of the hand calculation should be "close enough" to the spreadsheet results to give confidence in the reasonableness of the results. This qualification is added since discrepancies in rounding or method may result in small, say 5%, differences in results. Care needs to be exercised when such discrepancies exist to be sure that the difference is due to method rather than some hidden error in the spreadsheet.

10. Review the spreadsheet for the common errors in Attachment C.

11. Use the checklist included in block 9 of the SVF as a prompt for items to check for.

    NOTE: The use of additional task specific checklists and Spreadsheet auditing software such as Spreadsheet Professional[®3] are encouraged, if considered helpful to ensuring thorough verification.

12. If the spreadsheet contains macros, verification of the correct operation of the macros as part of the overall spreadsheet verification is required. As appropriate, things to check for include:

    • Does the macro correctly perform the intended function?

    • Do the buttons, dialog boxes, and menus work, as appropriate?

    • Are all the cell references within the macro correct?

    • If the macro involves file handling, what happens with duplicate or non-existent files?

    • Does the macro assume any default settings for the spreadsheet, such as worksheet names, which a user may change?

    • How does the macro cope with inappropriate data? How elegantly does it crash?

    • What happens when the user presses Escape during the macro execution?

    NOTE: Verification of the macro does not necessarily require checking the line by line VBA code. Verification may be performed by checking that the macro performs its intended function either by testing it or by using an alternate means to verify its correct performance.

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[3] Spreadsheet Professional[®] is a product of Spreadsheet Innovations Ltd, London, England.

13. If the spreadsheet contains add-in software, ensure that the software meets the minimum requirements in Section 5.0 and performs, as anticipated.

14. Report any errors, comments, or issues to the spreadsheet owner that require resolution.

     NOTE: The verifier shall not modify the original spreadsheet being verified to correct errors, assumptions etc. Comments are to be provided on the check copy of the spreadsheet to the spreadsheet owner/developer for resolution.

Spreadsheet Developer/Owner

15. Resolve errors, comments, and issues identified by the verifier to the satisfaction of the verifier.

16. If the scope of verification includes input data, complete input data verification in accordance with Section 4.6.2; otherwise, complete SVF approval in accordance with Section 4.6.3.

4.6.2   Spreadsheet Data Entry Verification

Prior to publishing or relying on the results of a single-use spreadsheet, verification that input data was correctly entered into the spreadsheet is required. This should normally be completed at the same time as formula verification described in Section 4.6.1. For multiple-use spreadsheets, verification that input data was correctly entered into the spreadsheet is required prior to publishing or relying on the results of each calculation using the spreadsheet.

Spreadsheet Developer/Owner

1. Confirm with the verifier the expected extent of data verification as originally established by Section 4.3.

Verifier

2. If input data entries are manual from a hard copy source, go to step 3. If entries are copy/paste from another spreadsheet or application, go to step 5.

3. For non-critical spreadsheets, check manual entries for accuracy by, at a minimum, checking a sampling of the input data entries against the original source of the information as indicated below.

    a. For spreadsheet files with less than 100 data elements, verify all input items and correct all errors found.

    b. For spreadsheet files with 101-500 data elements, verify that a 25% sample of input data taken at random is correct. If the observed error rate is less than 1% of the sample, complete the verification by correcting the errors. If the error rate exceeds 1%, correct the errors and draw another 25% sample and repeat the procedure. If the error rate for the second sample is less than 1%, complete the verification by correcting the errors. If the error rate for the second sample exceeds 1%, correct the errors and verify that all the remaining data elements are correct.

    c.   For spreadsheet files with over 500 data elements, verify that a 10% sample of the input data taken at random is correct. If the error rate is less than 1% of the sample, complete the verification by correcting the errors. If the error rate exceeds 1%, correct the errors and draw another 10% sample, and repeat the procedure. If the error rate for the second sample is less than 1%, complete the verification by correcting the errors. If the error rate for the second sample exceeds 1%, correct the errors and verify that all the remaining data elements are correct.

4.   For critical spreadsheet applications, check 100% of manual data entries for accuracy by comparing the entered data to the original source of the information.

5.   For data sets copied and pasted from another spreadsheet or application (e.g., data downloaded from TWINS), check the first and last values for appropriate placement and alignment in the spreadsheet cells and check that the sum of copied cells matches the sum of the original cells.

6.   Notify spreadsheet owner of any errors or discrepancies.

NOTE: The verifier shall not modify the original spreadsheet being verified to correct errors, assumptions, etc. Comments are to be provided on the check copy of the spreadsheet to the spreadsheet owner/developer for resolution.

Spreadsheet Developer/Owner

7.   Make and verify corrections.

8.   For single-use spreadsheets, ensure block 7 of the SVF indicates that the scope of the verification included the input data; if a situation arises where the formulas and input data need verification separately either:

    a.   Complete a separate SVF to indicate that the input data was verified or,

    b.   If the spreadsheet results are released in a published calculation or other document that contains a checklist, indicate on the calculation review checklist in TFC-ENG-DESIGN-C-10 (or document specific checklist) that the input data was verified.

9.   For multiple-use spreadsheets either:

    a.   Complete a new SVF for each spreadsheet use and indicate in block 7 that the scope of the verification included the input data, or

    b.   If the spreadsheet results are released in a published calculation or other document that contains a checklist, indicate on the calculation review checklist in TFC-ENG-DESIGN-C-10 (or document specific checklist) that the input data was verified.

Spreadsheet Developer/Owner and Verifier	10.	For SVFs completed in steps 8 or 9, proceed to Section 4.6.3 to complete the SVF approval process.
	11.	For input data verification recorded on calculation or document-specific checklists, follow the approval and record retention requirements of TFC-ENG-DESIGN-C-10 and/or TFC-ENG-DESIGN-C-25.

4.6.3   Completion of Spreadsheet Verification

Spreadsheet Developer/Owner	1.	Once cell formulas have been verified per Section 4.6.1 and, as appropriate, all input data has been verified per Section 4.6.2, and all comments from the verifier have been resolved,

    a.   For multiple-use spreadsheets, protect the cell formulas against inadvertent change as follows:

        1)   For each worksheet containing data entry cells, select any data entry cells and unlock them by unchecking the "Locked" check box from Format>Cells>Protection.

        2)   Protect each worksheet using the Tools>Protection>Protect Sheet features included in Excel, ensuring that the "Select locked cells" and "Select unlocked cells" boxes are checked.

        3)   If complete protection of the formulas as described in: 1) and 2) would prevent operation of the spreadsheet, macros, or add-in software, protect the spreadsheet to the maximum extent possible, and obtain a fresh copy of the spreadsheet from the share drive/protected source for each use.

        4)   A password may be added for additional protection, if desired.

    b.   For single-use spreadsheets, protect all worksheets in the workbook, following steps a. 2) and a. 4).

Spreadsheet Developer/Owner	2.	Complete approval of other documents and processing of SVF in accordance with Section 4.7.

4.7   Spreadsheet Approval and Release

Spreadsheet Developer/Owner	1.	Obtain approval signatures for any calculations or other technical documents that rely on the spreadsheet results in accordance with TFC-ENG-DESIGN-C-10 and/or TFC-ENG-DESIGN-C-25, ensuring that those documents reference the applicable SVF number.
	2.	For critical spreadsheets, obtain approval signatures for the Spreadsheet Description Document in accordance with TFC-ENG-DESIGN-C-25 or

TFC-ENG-DESIGN-C-10, as applicable, ensuring that the document references the applicable SVF number.

3. If the spreadsheet is for the 222-S Laboratory, ensure that any additional requirements specified in ATS-310, Section 8.14, are met prior to submitting the completed SVF to the Document Control Service Center.

Laboratory Configuration Control Board

4. If the spreadsheet is for the 222-S Laboratory and ATS-310, Section 8.14, requires approval of the spreadsheet by the Laboratory Configuration Control Board (LCCB), enter approval signature, name, and date in block 11 of the SVF.

Spreadsheet Developer/Owner

5. Maintain a copy of the completed SVF and associated documents in working files.

6. Submit the original hard copy signed SVF and a protected electronic copy of the spreadsheet (in *.xls or *.xlt format) to the Document Control Service Center for records retention and release.

NOTE: The SVF is a self-releasing form (i.e., no other form is required to release it through the release station). Submittal to the Document Control Service Center will ensure that the SVF, documents, and electronic file of the spreadsheet are entered into the Hanford Document Control System (HDCS) and that copies will be retrievable through both HDCS and the Integrated Document Management System (IDMS).

To transmit the electronic spreadsheet file to the Document Control Service Center either:

a. Add a folder named with the SVF number and revision (e.g., SVF-1234 Rev 0) to the WRPS Technical Records Staging Area folder on IDMS under Waste Tank Cleanup>Tank Operations>WRPS Shared Projects, and add the electronic spreadsheet file to that folder. Then take the hard copy SVF form to the Document Control Service Center; or

b. Alternatively, create a folder labeled with the SVF number and revision on a compact disc or USB memory card, copy the spreadsheet file to that folder, and take the compact disk or USB memory card to the Document Control Service Center together with the hard copy SVF form.

NOTE: The SVF and associated documents will not be released until the Document Control Service Center receives the electronic copy of the spreadsheet.

7. Submit associated documents to the Document Control Service Center for release in accordance with TFC-ENG-DESIGN-C-25.

8. For multiple-use spreadsheets, post a working copy of the spreadsheet to the appropriate share drive, ensuring that the copy matches the record copy submitted to the Document Control Service Center.

9. For critical single-use and critical multiple-use spreadsheets, complete the version description tab in HISI and other remaining tabs as applicable (see HISI User Guide). Insert required information directly in HISI or reference the document in which the information can be found (e.g., if it is contained in a released report). Attachment D provides guidance for completing the version description tab in HISI.

10. Submit version description in HISI for approval.

HISI Approvers   11. Review and approve software version description information in HISI. Resolve any comments with the spreadsheet developer/owner prior to approval.

4.8   Operation of Multiple-Use Spreadsheets

Spreadsheet Owner's Manager

1. Identify designated users of multiple-use spreadsheets.

2. Ensure that access to multiple-use spreadsheets on share drives is controlled such that only named users can modify the spreadsheets on the share drive.

Spreadsheet Owner/ Developer

3. Prior to placing a multiple-use spreadsheet on a share drive, ensure that the spreadsheet is protected as required by Section 4.6.3, step 1.

Authorized Spreadsheet Users

4. Prior to using a multiple-use spreadsheet accessed from a share drive, ensure that the spreadsheet version on the drive matches the latest verified version in HDCS.

5. If errors are discovered in verified multiple-use spreadsheets that affect the data quality, document the problem through the Problem Evaluation Request (PER) process in accordance with TFC-ESHQ-Q_C-C-01, and inform other authorized users of problem.

6. If revisions to multiple-use spreadsheets are required, go to Section 4.9.

4.9   Revisions to Verified Spreadsheets

Revisions to previously verified single-use or multiple-use spreadsheets may be required for several reasons such as to update calculations, to correct errors, or to implement new criteria in multiple-use spreadsheets.

Spreadsheet Developer/Owner

1. Identify the need to revise a previously verified spreadsheet.

   a. If an existing spreadsheet is to be revised to create a spreadsheet for a different purpose such that the spreadsheet takes on a new file name, treat that spreadsheet as a "new"

spreadsheet, follow Sections 4.3, 4.4, 4.5, and 4.6, and assign it a new SVF number in accordance with Section 4.6.

2. Identify required changes or new criteria to be incorporated in the spreadsheet.

3. Obtain a copy of the previous version of the spreadsheet.

    a. Ensure that the spreadsheet copy is the latest version by comparing to the most current version in HDCS.

    b. Contact a Document Service Center for assistance if you do not have access to HDCS.

4. Rename the spreadsheet file name with the next highest version number.

5. If the spreadsheet to be changed is a single-use spreadsheet that did not originally incorporate a change log, add a change log to the spreadsheet as a new worksheet that includes the following information:

    *   Version number
    *   A description of the change
    *   The name of the person making the change
    *   The date of the change
    *   The name of the person verifying the change
    *   The date of verification
    *   Reference to the corresponding SVF number for both the original and the new version.

6. If the spreadsheet to be changed is a multiple-use spreadsheet, update the change log with the following information:

    *   Version number
    *   A description of the change
    *   The name of the person making the change
    *   The date of the change
    *   The name of the person verifying the change
    *   The date of verification
    *   Reference to the corresponding SVF number for the new version.

7. If the spreadsheet has been previously protected, unprotect the minimum number of worksheets necessary to incorporate the required changes.

8. Revise the spreadsheet following the applicable spreadsheet development steps in Section 4.4.

9. Update applicable documents from Section 4.5, as necessary.

10. Obtain an SVF from Site Forms (site form A-6003-781) or from Microsoft Word >New>WRPS.

11. Obtain the current SVF number associated with the spreadsheet from the documentation worksheet or change log.

12. Ensure that the SVF number is the most current revision by comparing to the current released revision in HDCS; contact a Document Service Center for assistance if you do not have access to HDCS.

13. Assign a new SVF revision number by incrementing the current revision to the next number.

    NOTE: SVF numbers are assigned numeric sequential revision numbers (e.g., 0, 1, 2, 3…).

14. Enter the SVF number, including the revision number, in block 1 of the SVF.

15. Complete verification of spreadsheet and completion of SVF in accordance with Section 4.6 and the SVF form instructions.

    a. Ensure the scope of the verification is clearly identified in blocks 7 and 8 of the SVF.

    NOTE: For minor changes to a spreadsheet, only the changed portions of the spreadsheet require verification. For major spreadsheet changes, the entire spreadsheet shall be re-verified.

16. For critical single use and multiple-use spreadsheets, update information in HISI for the spreadsheet, as necessary (e.g., version description).

17. Approve and release the SVF, spreadsheet electronic file, and associated documents in accordance with Section 4.7.

4.10 Use of this Procedure by Subcontractors

This section of the procedure applies to subcontractors working on task-based contracts for the development and verification of spreadsheets, when the procedure is specified in the statement of work for the contract. This section of the procedure does not apply to staff augmentation subcontract engineers working under the TOC QA program, who should follow the previous sections of the procedure as written. Outside subcontractors tasked to perform calculations or to develop spreadsheets under this procedure must meet the general requirements specified in Section 3.0. The following steps provide additional guidance to WRPS Buyer's Technical Representatives (BTR) or technical Points of Contact (POC) and outside subcontractors on the use of this procedure.

WRPS BTR or Technical POC

1. Ensure that outside subcontractors tasked to perform calculations or develop spreadsheets under this procedure meet the requirements specified in Section 3.0.

2. Include reference to this procedure in the statement of work for contracts/tasks requiring spreadsheet development and ensure that the subcontractor personnel have access to either a hard copy of the procedure or are able to access the procedure from HLAN.

3. Ensure that subcontractor personnel have access to the HDNS for obtaining SVF numbers or obtain numbers for the subcontractor for each SVF requested.

    NOTE: If obtaining numbers for the subcontractor, it is preferable not to take out a block of numbers, which may then go unused, but to obtain the numbers individually at the time they are needed.

4. As requested, concur on the category of each spreadsheet to be developed by the subcontractor to ensure that the appropriate level of documentation and verification is performed.

Subcontractor
Personnel

5. Follow this procedure, as written, for the development, documentation, verification, approval, and revision of spreadsheets with the following clarifications.

6. Ensure that personnel preparing and verifying spreadsheets meet the general requirements provided in Section 3.0.

7. Where concurrence is required from the spreadsheet owner's manager on the category of spreadsheet selected, obtain this concurrence from the WRPS BTR or technical POC.

8. Obtain SVF numbers from HDNS or from the WRPS BTR/Technical POC if HDNS access is not available.

9. Ensure all approval signatures on the SVF are subcontractor personnel, with the responsible subcontractor's technical manager for the task signing as spreadsheet owner's manager.

10. Where this procedure calls out TFC-ENG-DESIGN-C-10 and/or TFC-ENG-DESIGN-C-25 for documentation of calculations or technical documents, compliance with those procedures is only required if those procedures have been invoked in the statement of work for the task; otherwise, the subcontractor's applicable procedures for calculations and technical documents under their QA program should be invoked instead.

11. On completion of the spreadsheet verification, ensure that both the completed SVF and an electronic file of the spreadsheet are turned over to the point of contact specified in the statement of work.

WRPS BTR or
Technical POC

12. Review and accept subcontractor's submitted calculations in accordance with TFC-ENG-DESIGN-C-10.

13. Submit subcontractor's completed SVFs, associated electronic spreadsheet files, and associated documents to the Document Control Service Center in accordance with Section 4.7.

14. For any critical single-use or critical multiple-use spreadsheets developed by a subcontractor for use by WRPS, register the spreadsheet in HISI in accordance with Section 4.7.

5.0   DEFINITIONS

Acceptable Excel add-in software. There are many Excel "add-in" software packages available that are able to provide enhancements to Excel's standard capabilities. Use of such packages without additional verification and validation is acceptable if they meet the following criteria. The "add-in" software must be commercially available software, suitable for its intended purpose, and must be a production version of the software (e.g. not be a "beta" or test version.) The software must be scanned for viruses prior to installation. If the add-in software does not meet the previous definition, it must be verified in accordance with the requirements of TFC-BSM-IRM_HS-C-01 prior to use.

Macros. In Excel, a macro is a module containing commands or functions: i.e., a series of actions used to automate a task. This has the following advantages: a) saving time in performing repeated actions; b) reducing the possibility of introducing errors into the spreadsheet; or c) enabling users to perform complex operations in a single step. There are no restrictions within this procedure on the use of macros written in Excel's built-in programming language VBA (Visual Basic for Applications), with the exception that the correct functioning of the macro must be verified and documented as part of the overall spreadsheet verification.

Spreadsheet categories. There are four categories of spreadsheets discussed in this procedure, as follows:

Computation spreadsheets. Computation spreadsheets are simple spreadsheets used for non-critical tasks. Computation spreadsheets are used for preliminary or rough-order-of-magnitude work and they are not used to support published technical documents or to support data stored in database applications, such as TWINS. Spreadsheets used in published technical documents or in database applications must be defined as one of the other categories of spreadsheets below. Computation spreadsheets may be used to perform simple operational support calculations for general service equipment or activities. They are not to be used for calculations associated with safety class or safety significant equipment or to verify safety basis or environmental compliance. Computation spreadsheets must not use macros, third-party "add-in" software (i.e., not supplied by Microsoft), or contain links to other workbooks. If the spreadsheet meets these requirements then there are no procedural requirements for documentation or formal verification of the spreadsheet. Checking of the spreadsheet is recommended. The results of computation spreadsheets shall not be presented to the Office of River Protection or external regulators, unless the status of the spreadsheet results and extent of verification are clearly communicated.

Non-critical spreadsheets. Non-critical spreadsheets perform calculations that are associated with the design or operation of general service equipment or are associated with typical operational support activities or provide results that will be published in a

technical document, database, or other similar software application. Non-critical spreadsheets also include spreadsheets used to generate graphs or tables in published technical documents. Examples include spreadsheets prepared in support of Best Basis Inventory development, general operational support spreadsheets, or spreadsheets prepared in support of individual engineering calculations for general service equipment. The category does not include critical spreadsheet applications such as spreadsheets used to perform safety basis hazard analysis calculations, calculations associated with safety-class or safety significant equipment, or spreadsheets that verify safety basis compliance. For a non-critical -spreadsheet, the spreadsheet itself may be the end product and a separate published document is not always required, provided that certain key information is provided in the spreadsheet. These spreadsheets require formal verification prior to relying on their results. Published documentation can be required as determined by management for any non-critical spreadsheets that are considered to have a high importance, visibility, risk or significant cost or schedule implications that would warrant a higher level of documentation.

Critical spreadsheets. This category of spreadsheets includes spreadsheets used to support or perform safety analysis calculations or the design or operation of safety-class or safety significant equipment; spreadsheets that are used to classify, design or analyze nuclear facilities; spreadsheets that perform a safety function as defined in a DOE approved documented safety analysis; and spreadsheets that perform a hazard control function in support of a technical safety requirement (TSR) or protection from nuclear facility hazards. This category of spreadsheet requires a published technical document describing the purpose, input data, assumptions, methodology, verification, and results of the spreadsheet. These spreadsheets require formal verification prior to relying on their results.

Multiple-use spreadsheets. This category of spreadsheet includes "master" spreadsheets or spreadsheet templates that are used multiple times for performing routine or standardized calculations. The category also includes spreadsheets that are accessed by multiple users. Key examples include the waste transfer compatibility spreadsheet that is used for assessing compliance of waste transfers with numerous compatibility program criteria and TSR administrative controls. Other examples include the flammable gas waste group spreadsheet and time to lower flammability spreadsheets used to perform calculations to assess compliance with TSR requirements. Multiple-use spreadsheets may be either critical or non-critical depending on the end use of the spreadsheet results. All multiple-use spreadsheets require formal verification prior to relying on their results.

6.0   RECORDS

The following records are generated during the performance of this procedure:

Record Description	Vital Record Y/N	QA Record Y/N	QA Record Retention L/NP	NARA Retention Schedule	Other Retention Requirements	Records Custodian
Spreadsheet Verification and Release Forms	N	Y	L	ADM 17.32a	N/A	IRM Service Provider
Spreadsheet Electronic Files	N	Y	L	ADM 17.32a	N/A	IRM Service Provider
Spreadsheet Description Documents	N	Y	L	ADM 17.32a	N/A	IRM Service Provider

The identified record custodian is responsible for record retention in accordance with TFC-BSM-IRM_DC-C-02.

7.0   SOURCES

7.1   Requirements

1.   TFC-PLN-02, "Quality Assurance Program Description."

7.2   References

1.   TFC-BSM-IRM_DC-C-02, "Records Management."

2.   TFC-BSM-IRM_HS-C-01, "Software Development, Implementation, and Management."

3.   TFC-ENG-DESIGN-C-10, "Engineering Calculations."

4.   TFC-ENG-DESIGN-C-25, "Technical Document Control."

5.   TFC-ESHQ-Q_C-C-01, "Problem Evaluation Request."

Figure 1. Spreadsheet Verification Flowchart.

ENGINEERING

SPREADSHEET DEVELOPMENT AND VERIFICATION

Document   **TFC-ENG-DESIGN-C-32, REV B-11**
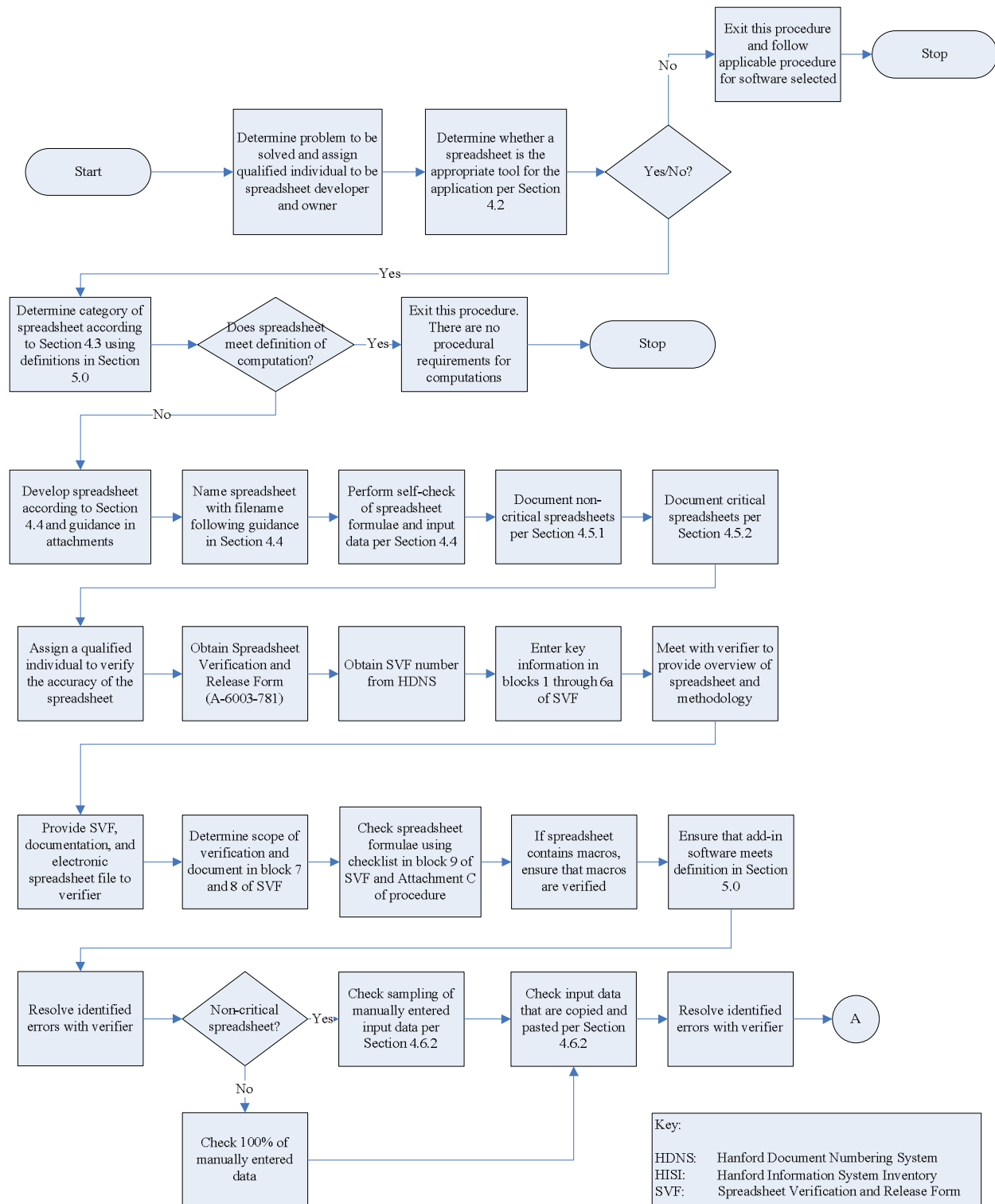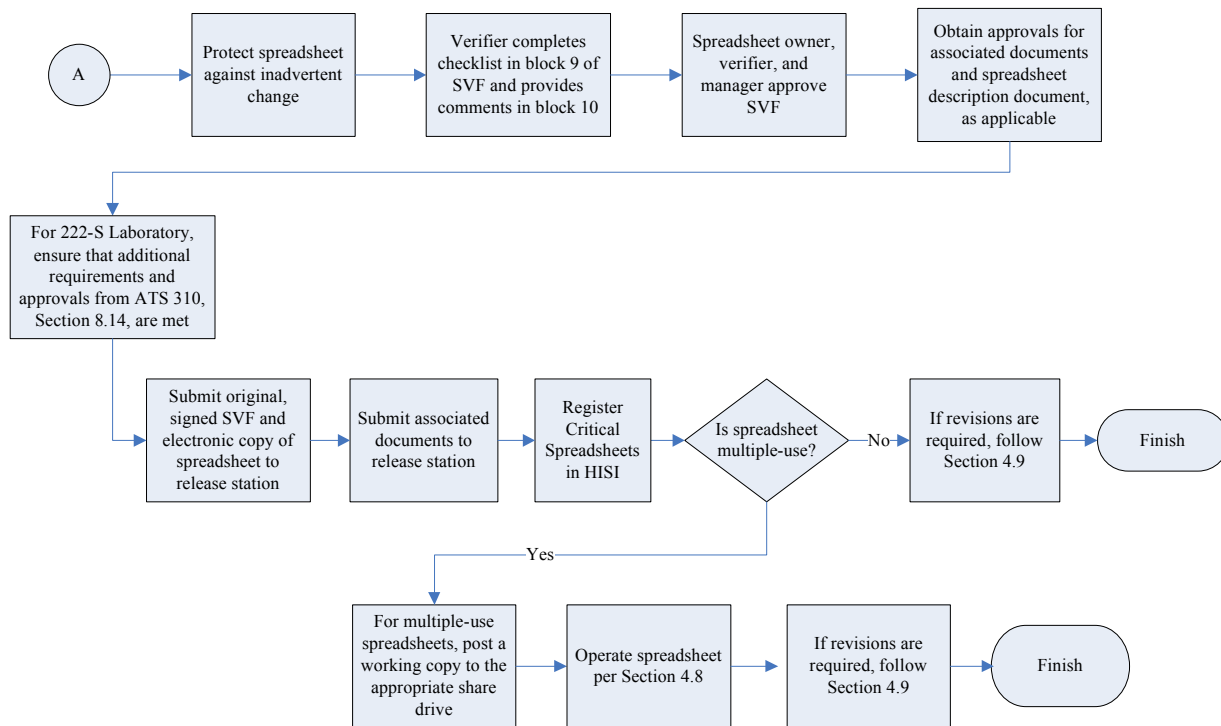Page   **27 of 37**
Effective Date   **June 2, 2009**

Figure 1. Spreadsheet Verification Flowchart (cont).

ATTACHMENT A - GOOD SPREADSHEET DESIGN PRACTICES

A number of good practices for spreadsheet design are well established in the literature on spreadsheet development. Following these standard practices during spreadsheet design will help ensure that the final spreadsheet is easier to understand for both a user and a verifier and significantly reduce the risk of errors in the final spreadsheet product. These practices are not mandatory but should be followed to the extent practical when developing new spreadsheets.

1.   A Modular Design

Although at least one paper suggests building spreadsheets in which everything is contained on a single worksheet, this is not the generally accepted practice for good spreadsheet design and is not recommended. Other than for relatively small and simple spreadsheets, it is better practice to use a modular design that utilizes multiple worksheets, with each worksheet dedicated to a specific purpose. It will be much easier to manage, navigate, and verify a well designed modular spreadsheet than it is to wade through hundreds or thousands of rows and columns crammed onto a single worksheet.

- Using different worksheets, whenever different column headings are required makes it easier to expand the spreadsheet in future, avoiding the difficulty of column inserted between headings at the top of a worksheet accidentally splitting different headings located lower down the worksheet.

- If a spreadsheet contains sections which can be usefully repeated, such as a data for different waste tanks, the best way to present it in a spreadsheet is to use one worksheet for each repeatable block. By standardizing on the layout of the first worksheet, the spreadsheet can be developed quicker by copying the standardized worksheet, as required.

2.   Separate Inputs, Calculations, and Results

It is good practice to provide a clear separation between the area of a workbook in which the user enters data, the area that perform calculations on that data, and the area in which the final results of the calculations are displayed. This practice makes it easier to identify all the input data used in a spreadsheet and greatly reduces the risk that calculations will be accidentally overwritten with input data. Providing distinct color coding of the data entry cells helps to clearly define the input data area of the worksheet. Providing a separate area for the calculations makes it easier to verify and maintain the spreadsheet by keeping the calculations together in a defined part of the spreadsheet. Keeping the results separate from the input and calculations makes it easier to print final reports and to clearly distinguish between results and their basis.

This separation will most typically be achieved by the use of separate worksheets: one for input data, one for calculations, and one for results. With most tank farm spreadsheets that require a significant volume of input data, this will be the preferred arrangement.

ATTACHMENT A - GOOD SPREADSHEET DESIGN PRACTICES (cont.)

If the spreadsheet is small enough, the separation may be achieved on an individual worksheet. Two ways to achieve this are common: top-to-bottom and diagonal. In the top-to-bottom arrangement, the top of the worksheet is dedicated to the input data, the middle section of the worksheet contains the calculations, and the bottom of the worksheet displays the results. An alternate and preferred arrangement for a single worksheet is to utilize a diagonal arrangement in which each section is added below and to the right of the section above it. The advantage of this arrangement is that none of the sections share rows or columns with each other, making it easier to add or delete rows or columns without risking impacting another section of the worksheet.

3.   Keep Formulas Simple

It is good practice to avoid the creation of long complex formulas containing multiple functions or complex logic. Formulas will be much easier to understand and verify if long formulas are broken down into their intermediate steps and formulas are limited to one or two functions in a given cell. Although more rows or columns will be required to achieve this, the resulting formulas will be much easier for a verifier to follow and check, will be less prone to error, and will result in a more robust final product.

One of the most common ways that formulas become too long is by including multiple nested IF commands. Frequently, this problem can be overcome by using table lookup functions, such as VLOOKUP (vertical lookup) or HLOOKUP (horizontal lookup).

4.   Use One Formula per Row or Column

As far as possible, formulas should be written so that a single formula can be copied across the entire row of calculations or down the entire column. Using one formula per row has the following advantages:

- Quicker development, because every formula can be written in a single column, then copied across all other columns

- Effective testing, especially when you use formula maps generated by software such as Spreadsheet Professional that distinguish between unique and copied formulas

- Robust updating and maintenance, because every time a formula is changed in a cell you know that it should be copied across the rest of the row. One of the most common causes of errors in formulas is when a change is made but old versions of the formula are left lurking behind

- Straightforward documentation in a specification which has one definition for each row of the final spreadsheet.

ATTACHMENT A - GOOD SPREADSHEET DESIGN PRACTICES (cont.)

5.   **Avoid Creating Circular References**

It is good practice to design a spreadsheet so that the logic flows from front to back, top to bottom, and left to right. This makes the spreadsheet easier to understand and reduces the risk of introducing a circular reference to the calculation.

For example, each cell reference in a formula should refer either to an input or calculation further up the same column or to an input or calculation on an earlier worksheet in the workbook, or to a calculation further down the worksheet but in an earlier column.

6.   **Include a Documentation Worksheet**

It is good practice, and required by this procedure in Section 4.5, to provide some internal documentation within the spreadsheet. The extent of documentation will depend on the importance and complexity of the spreadsheet. However, the documentation will provide key information about the spreadsheet to guide future users and verifiers of the spreadsheet and avoid the need to consult the original developer of the spreadsheet during verification or use. Requirements for documentation worksheets within this procedure are discussed in Section 4.5.

ATTACHMENT B - SPREADSHEET HINTS AND TIPS

While not being appropriate to all spreadsheets, the ideas in this section can be useful ways to make the spreadsheet easier to understand and use.

Color Coding

Color coding is a useful technique to make spreadsheets easier to use and can be used to more clearly distinguish between separate sections of a spreadsheet as discussed in Attachment A. If you use dark colors for text, then black and white printouts will be largely unaffected, but the difference will be visible on screen. Using pale colors for shading cells will be visible on printouts, but may become indistinct on photocopies or faxes.

Examples of using color coding include:

- Separating inputs from calculations by making all of the cells requiring inputs the same color
- Separating types of inputs
- Highlighting cells which are linked to external spreadsheets
- Highlighting the cells modified when you made a particular change to the spreadsheet, making it much easier to track changes or, if necessary, reverse the change at a later date.

Units

The inclusion of a units column on every worksheet will tell you what is expected in each input cell and what is being presented in calculations. Verification of spreadsheet formulas should verify the dimensional consistency of formulas.

Natural Language Formulas

For simple spreadsheets, it can be useful to include an extra column containing natural language translations of the formulas in the spreadsheet.

This helps to make the calculations in a spreadsheet easy to understand, makes important logical assumptions more transparent to anyone using the model and makes it possible for an independent tester to check the coding in the spreadsheet.

When the spreadsheet development and verification is complete, the column containing the formula can be safely hidden, if desired, but not deleted to keep it as a record of what the spreadsheet is attempting to do.

Alternatively, spreadsheet auditing software packages are able to translate cell formulas into natural language formulas based on row and column headings in the spreadsheet. While potentially very powerful, caution needs to be exercised when using these translators since poor spreadsheet design and the use of subheadings can confuse the translators and make the translations incorrect. Spreadsheet Professional includes options that enable the user to specify the location of row and column headings and may be able to overcome this limitation.

ATTACHMENT B - SPREADSHEET HINTS AND TIPS (cont.)

Use Named Ranges

Consider using range names when developing a spreadsheet.

Allocating meaningful range names to areas or cells within a spreadsheet can make the formulas in a spreadsheet easier to understand and reduce the risk of errors made by referring to the wrong cell. This is most useful when a cell is referenced in a formula a long way from where it is calculated, particularly when the input cell is contained on a different worksheet than the formula.

When referring to nearby cells, it is preferable to keep with cell references rather than range names. Having the referenced cells close to their point of reference makes it relatively easy to trace and understand the formula, and avoiding range names will keep the formula definition shorter.

If using range names, include a table of range names and their associated cells on the documentation worksheet of the spreadsheet.

Build in Error Traps

It is good practice to include checks for errors in a spreadsheet. These can be set up to check for errors in the input data provided, or for errors in the spreadsheet formulas.

Cross casting is the process of checking that the totals in the rows and columns of a spreadsheet are consistent. This can prove useful for detecting errors introduced by the insertion of rows or columns.

Use Data Validation

- Especially for multiple-use spreadsheets, use the data validation feature of Excel, available under Data>Validation… The feature allows prompting the user for the correct data and will display a warning if inputs lie outside a specified valid range or are the wrong type of data.

- An alternate means of performing data validation is to use conditional formatting to identify if a result is outside an acceptable range (i.e. color cell in, say, red if the data is outside specified values).

Macros

- Macros can be used to automate repetitive tasks within a spreadsheet and can improve the spreadsheet usability. However, care needs to be taken to ensure that the correct functioning of the macro is verified. A useful paper may be found at Excel Macros.

ATTACHMENT C - COMMON SPREADSHEET ERRORS

The following represent some of the most common spreadsheet errors. It pays to be alert for these common errors during verification of the spreadsheet.

Formulas Not Copied

One of the easiest ways to introduce an error into a spreadsheet is to update the formula in a cell and forget to copy the new formula across into the other cells in a row. By using a formula map and a design in which all formulas are copied across all rows, this mistake can be noticed very quickly.

Wrong Reference

Nearly every formula in a spreadsheet refers back to another input or calculation. With the quantity of references in any large spreadsheet, it is inevitable that you will make mistakes and refer to the wrong cell. Sometimes, the resulting formula will produce a meaningless result making it easy to spot with some simple numerical testing. If you are unlucky, the error in the result will be more subtle.

The only way to check for wrong references with any confidence is to check every unique formula in the spreadsheet. In Excel, checking references is made easier if you use the auditing toolbar. This allows you to trace the precedent cells graphically.

Sum Over the Wrong Range

A similar mistake is to include the wrong cell reference in a SUM formula. It is particularly easy to introduce this error when you insert an extra row in a block of cells that are being summed. Insert a row in the middle of the block and the formula will automatically adjust to include the extra row, but insert a row immediately above or below the block, and the new row will be omitted from the formula.

You can build internal checks of the sums in a spreadsheet by using cross casting, as described in Attachment B. When testing a spreadsheet, Excel's trace precedents feature helps to find errors of this type by showing them graphically.

Relative and Absolute References

Another commonly found error is caused by confusion between relative and absolute references. A cell reference in a formula of the form '=D4' will change if you copy the formula across the row to E4, F4 and so on. Copied down a column it will change to D5, D6, etc. If you use the reference 'D4' it will not change when copied across or down. You can also use semi-absolute references of the form $D4 or D$4.

The most common mistake is using a relative reference instead of an absolute one. This is quite easy to spot numerically, but if you use an absolute reference in place of a relative one it can be much more difficult to spot. Again, the only way to find this mistake reliably is to go through all of the unique formulas in the spreadsheet.

ATTACHMENT C – COMMON SPREADSHEET ERRORS (cont.)

Units Errors

Mixing up the appropriate units for the elements in a calculation is another frequently occurring problem. Finding such errors can be helped by features such as inclusion of a units column to make tracing through the calculation clearer. It is also good practice to try to avoid switching between units, except when absolutely necessary.

Performing a dimensional analysis of formulas will ensure that errors in units are identified.

Commonly Misused Functions

Certain functions are frequently used incorrectly such as the lookup and reference functions, VLOOKUP, HLOOKUP, INDEX, and MATCH. It is important to construct the VLOOKUP statement correctly to ensure that an exact rather than an approximate match to the desired value is obtained. See the following presentation for additional information on VLOOKUP errors: VLOOKUP Errors

Complicated IF statements, especially nested IF statements, are also particularly prone to error. See the following presentation for information on IF statement errors: IF Statement Errors

These functions are often very useful, but make sure that you understand exactly how they work before using them in your spreadsheet. By making the formulas in your spreadsheet easy to understand, you reduce the risk of introducing errors and increase the chances that a verifier will find your mistakes.

Spreadsheet auditing software is able to check for many function problems.

Linked Workbooks

Beware of making structural changes, such as inserting and deleting rows/columns, to linked workbooks. It is essential to have both workbooks open when making structural changes to a called workbook to ensure that the change is reflected in the workbook containing the link. See the following presentation for more information: Linked Workbook Errors

Hidden Cells/Pages

Hidden cells, pages, or ranges can cause difficulty both during the construction of a spreadsheet and during the verification. If you are developing or modifying a spreadsheet, hidden cells may result in the inclusion of more than is expected in a calculation, such as a SUM. Likewise, if you copy across hidden areas, you may well overwrite formulas that are important to the spreadsheet. See the following presentation for more information: Hidden Cell Errors

Additional Information

Additional useful information discussing how errors happen in Excel can be found using the following link: Common Excel Errors

ATTACHMENT D - GUIDANCE FOR COMPLETING THE VERSION DESCRIPTION TAB IN HISI (HANFORD INFORMATION SYSTEMS INVENTORY)

HISI Version Description Tab	Documentation
Functional Requirements Definition	Insert a link to the Spreadsheet Description Document.
Alternatives Analysis	Enter the following statement: "Selection of a spreadsheet for this application followed the process described in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification*." Enter a link to TFC-ENG-DESIGN-C-32. For Excel spreadsheets also enter the following statement: "Excel was chosen for this application because it is the site standard utility calculation software and will perform the necessary functions." For other utility calculation software enter the factors leading to its selection for use.
Software Management Plan	Enter a link to the Spreadsheet Description Document and a link to TFC-ENG-DESIGN-C-32, "Spreadsheet Development and Verification."
Software Configuration Management Plan	Enter the following statement: "This software application is documented and controlled in accordance with TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification*" and the Spreadsheet Description Document." Enter links to TFC-ENG-DESIGN-C-32 and the Spreadsheet Description Document.
Acquisition Documents	For Excel spreadsheets enter "Not applicable; Excel software is available as a site standard from software distribution. Therefore, no specific acquisition documentation exists." For other utility calculation software provide reference numbers for acquisition documents, as applicable.
Software Requirements Specification	Enter a link to the Spreadsheet Description Document.
Software Design Description	Enter a link to the Spreadsheet Description Document.
Requirements Traceability Matrix	Enter the following statement: All requirements related to spreadsheet development and control (not in matrix form) are contained in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification* and the Spreadsheet Description Document." Enter links to TFC-ENG-DESIGN-C-32 and the Spreadsheet Description Document.
Code Walkthrough	Enter the following statement: "Code walkthrough is performed following the process in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification* and results are documented on the Spreadsheet Verification Form." Enter links to TFC-ENG-DESIGN-C-32 and the Spreadsheet Verification Form.
User Documents	Enter a link to the Spreadsheet Description Document.

ATTACHMENT D – GUIDANCE FOR COMPLETING THE VERSION DESCRIPTION TAB IN HISI (HANFORD INFORMATION SYSTEMS INVENTORY) (cont.)

HISI Version Description Tab	Documentation
Unit Testing	Enter the following statement: "Testing is performed following the process in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification* and results are documented on the Spreadsheet Verification Form." Enter links to TFC-ENG-DESIGN-C-32 and the Spreadsheet Verification Form.
Test Plan And Cases	Enter the following statement: "Testing is performed following the process in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification* and results are documented on the Spreadsheet Verification Form." Enter links to TFC-ENG-DESIGN-C-32 and the Spreadsheet Verification Form.
Acceptance Test Report	Enter the following statement: "Testing is performed following the process in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification* and results are documented on the Spreadsheet Verification Form." Enter links to TFC-ENG-DESIGN-C-32 and the Spreadsheet Verification Form.
Contingency Plan	Enter a link to the Spreadsheet Description Document.
Software Installation Plan	Enter the following statement: "Spreadsheets will be developed and operated on site standard personal work stations. The only installation activity will be the retrieval of master files for development of revisions to previously verified spreadsheets. These file are typically maintained in a network share area accessible to authorized users, as described in the Spreadsheet Description Document" Enter a link to the Spreadsheet Description Document.
User Qualification	Enter the following statement: "Minimum qualifications for the spreadsheet developer and verifier are identified in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification.* Additional qualification requirements, if any, are discussed in the Spreadsheet Description Document." Enter a link to TFC-ENG-DESIGN-C-32 and to the Spreadsheet Description Document, if applicable.

ATTACHMENT D – GUIDANCE FOR COMPLETING THE VERSION DESCRIPTION TAB IN HISI (HANFORD INFORMATION SYSTEMS INVENTORY) (cont.)

HISI Version Description Tab	Documentation
User Training	Enter the following statement: "Initial training of engineering staff includes software quality assurance requirements and spreadsheet verification as part of the Core Engineer qualification process (Qualification Card 350850). [alternately, enter the initial training requirement for scientific staff that do not complete the Core Engineer card] Training on changes to the spreadsheet development and verification process is specified on the Administrative Document Change Request form for each change to the procedure (TFC-ENG-DESIGN-C-32)." Enter links to the applicable qualification card and TFC-BSM-AD-C-01, *Administrative Document development and Maintenance.*
Operational Testing	Enter a link to the Spreadsheet Verification Form.
Change Request / Problem Report	Enter the following statement: "Spreadsheet change control and problem reporting/resolution follow the process in TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification."* Enter a link to TFC-ENG-DESIGN-C-32.
Retirement Plan Checklist	If there is any existing retirement plan for the spreadsheet, list it here. If no retirement plan exists, enter "There are no current plans for retirement of this spreadsheet."
Other Documents	List other documentation, if any, related to development and control of the spreadsheet, or enter "none."